

CLAIMS

1. (Currently Amended) A method of forming a patterned thin film, ~~wherein said thin film is not a monolayer, said process comprising: the step of~~

immersing a substrate, selected from the group consisting of a metal, a metal oxide, a semiconductor, a metal alloy, a semiconductor alloy, a polymer, an organic solid and a combination thereof, into a surface derivatizing liquid solution of an organic molecular species, said organic molecular species having reactive functional head groups and tail groups;

said substrate being immersed in contact with said liquid solution of said organic molecular species at a temperature and for a time period sufficient to allow said functional head group to chemically react with and chemically bind to and pack onto a surface of said substrate and interact with adjacent molecules to form a single chemical entity which is a relatively ordered molecular monolayer that is chemically bound to said substrate forming a self-assembled mono-molecular layer;

said tail group provides means for chemical differentiation of patterned and unpatterned regions of a coated surface;

withdrawing said substrate containing said self-assembled mono-molecular layer thereon and placing a mask having one or more transparent and opaque regions onto a top surface of said self-assembled mono-molecular layer on said substrate;

exposing said self-assembled molecular layer to radiation, modulated spatially in intensity in regions defined by said one or more of said regions in said mask transparent to radiation with the result that said self-assembled mono-molecular layer absorbs incident radiation in said transparent regions, thereby only modifying/removing said self-assembled mono-molecular layer beneath said transparent regions of said mask;

producing a chemically differentiated surface between patterned and unpatterned regions of said substrate surface, so that after modification, said self-assembled mono-molecular layer has a discontinuous pattern;

depositing immersing said substrate containing said self-assembled mono-molecular layer having said discontinuous pattern into a liquid dipping solution of a thin film material in liquid solution on a substrate having thereon a patterned underlayer of a self assembled monolayer having patterned and unpatterned regions for a time sufficient to allow a thin film to be physically adsorbed to said substrate forming a thin film comprising a plurality of layers of molecules and/or atoms;

removing said substrate from said liquid dipping solution to obtain a patterned article having thin film material only in certain regions thus forming a patterned thin film on said substrate surface; and

wherein after said immersion treatment, said patterned thin film having been formed only on a surface of said substrate is not coated with said self assembled monolayer and the original self-assembled monomolecular layer has a discontinuous pattern;

~~wherein said self-assembled monolayer is formed from an organic molecular species having a functional head group for interaction with said substrate and a tail group for chemical differentiation of patterned and unpatterned regions of said self-assembled monolayer such that the~~ because said patterned thin film is formed only on a said surface of the said substrate not coated with the said self-assembled monolayer, so there is not a need for further post-deposition processing.

2.(Canceled) The method of Claim 1 wherein said substrate is selected from the group consisting of a metal, a metal oxide, a semiconductor, a metal alloy, a semiconductor alloy, a polymer, an organic solid and a combination thereof.

3. (Currently Amended) The method of Claim 2 1 wherein said substrate is an irregularly shaped substrate.

4. (Currently Amended) The method of Claim 2 1 wherein said substrate is a solid substrate having a flexible, curved or planar geometry.

5. (Canceled) the method of Claim 1 wherein said self-assembled monolayer has patterned and unpatterned regions and is prepared by a process comprising the steps of :

providing a stamp having a surface;

coating said surface of said stamp with an organic molecular species to produce a coated surface, said organic molecular species having a head functional group capable of interacting with said surface of said substrate, and a tail group for chemical differentiation of said patterned and unpatterned regions of said coated surface;

placing said coated surface in contact with said substrate for a length of time sufficient to transfer said self-assembled monolayer of said organic molecular species from said stamp to said substrate; and

removing said stamp.

6.(Canceled) The method of Claim 5 wherein said stamp is an elastomeric stamp.

7. .(Canceled) The method of Claim 5 wherein said stamp has at least one indented and at least one non-indented surface.

8. (Canceled) The method of Claim 7, wherein said transfer is in pattern defined by the topography of said stamp.

9. (Currently Amended) The method of Claim 5 1 wherein said organic molecular species has a functional head group selected from the group consisting of a phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphate, phosphite, phosphazine, azide, hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, silane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl), selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate and a combination thereof.

10. (Currently Amended) The method of Claim 5 1 wherein said organic molecular species has a functional tail group selected from the group consisting of: a hydrocarbon, partially halogenated hydrocarbon, fully halogenated hydrocarbon, phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphite, phosphate, phosphazine, azide, hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, silane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl), selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate, dialkylthiophosphate and a combination thereof.

11. (Currently Amended) The method of Claim 5 1 wherein said organic molecular species comprises one or more compounds selected from the group consisting of: a silane, a phosphonic acid, a carboxylic acid, a hydroxamic acid, a thiol, an amine, a phosphine, a hydrocarbon, a partially halogenated hydrocarbon, a fully halogenated hydrocarbon.

12. (Currently Amended) The method of Claim 5 1 wherein said organic molecular species comprises (tridecafluoro-1,1,2,2-tetrahydrooctyl)trichlorosilane.

13. (Currently Amended) The method of Claim 5 1 wherein said organic molecular species octadecylphosphonic acid.

14. (Withdrawn) The method of Claim 1, wherein said self-assembled monolayer has patterned and unpatterned regions and is prepared by a process comprising the steps of:

contacting the substrate and a solution comprising an organic molecular species having a head functional group capable of interacting with said surface of said substrate, and a tail group for chemical differentiation, said contacting being at a temperature and for a length of time sufficient to bind said functional head groups to said surface of said substrate; and

exposing said self-assembled molecular monolayer to radiation modulated spatially in intensity with a mask having one or more regions transparent to radiation to chemically modify said self assembled molecular monolayer in a chemically distinct pattern defined by said transparent regions of said mask.

15 (Withdrawn) The method of Claim 14 wherein said radiation is light.

16.(Withdrawn) The method of Claim 14, wherein said mask is a photomask.

17. (Withdrawn) The method of Claim 14 wherein said contacting is carried out by immersing said substrate in solution comprising said organic molecular species.

18. (Withdrawn) The method of claim 14 wherein said organic molecular species has a functional head group selected from the group consisting of phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphite, phosphate, phosphazine, azide, hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, silane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl, selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate, dialkylthiophosphate and a combination thereof.

19. (Withdrawn) The method of Claim 14 wherein said organic molecular species has a functional tail group selected from the group consisting of a hydrocarbon, partially halogenated hydrocarbon, fully halogenated hydrocarbon, phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphite, phosphate, phosphazine, azide, hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, silane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl), selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate, dialkylthiophosphate and a combination thereof.
20. (Withdrawn) The method of Claim 14 wherein said self-assembled molecule comprises (tridecafluoro 1,1,2,2-tetrahydrooctyl) trichlorosilane..
21. (Withdrawn) The method of Claim 14 wherein said self-assembled molecule comprises octadecylphosphonic acid.
22. (Canceled) The method of Claim 1 wherein said thin film is deposited by a solution-based deposition process.
23. (Currently Amended) The method of Claim 1 wherein said film material is selected from the group consisting of : an organic molecule, a short-chain organic oligomer, a long-chain organic polymer, a photoreist, an organic-inorganic hybrid material, an organo-metallic complex, a nanoparticle of metal oxide, a nanoparticle of semiconductor, a silica particle, an inorganic salt and a mixture thereof.
24. (Currently Amended) The method of Claim 23, wherein said film material is an organic-inorganic hybrid material is selected from the group consisting of $(C_6H_5C_2H_4NH_3)_2SnI_4$, $(C_4H_9NH_3)_2CH_3NH_3Sn_2I_7$, $(C_6H_5C_2H_4NH_3)_2CH_3NH_3Sn_2I_7$, $H_3NC_4H_8NH_3)_2SnI_4$ and mixture thereof.
25. (Original) The method of Claim 23, wherein said photoresist is a positive deepworking UV photoresist.

26. (Original) The method of Claim 23, wherein said long-chain organic polymer is polymethyl methacrylate/methyl methacrylate copolymer.

27. (Original) The method of Claim 23, wherein said metallo-organic complex is tin 2-ethylhexanoate.

28. (Canceled) The method of Claim 22, wherein said solution-based deposition process is a spin coating process comprising the steps of:

flooding said substrate having thereon said patterned self-assembled molecular monolayer with a solution comprising a thin film material or a precursor thereof; and spinning to deposit said thin film material thereby forming a patterned thin film on said substrate.

29. (Canceled) The method of Claim 22, wherein said solution-based deposition process is an immersion-coating process comprising the steps of:

immersing said substrate having thereon said patterned self-assembled molecular monolayer into solution comprising said thin film material or a precursor thereof; and withdrawing said substrate from solution, thereby forming a patterned thin film on said substrate.

30. (Previously Presented) A method of forming a patterned monolayer thin film, comprising the step of :

depositing an organic molecular species on a first portion of a surface of a substrate, the organic molecular species coating particular portions of the surface forming patterned and unpatterned regions, the organic molecular species having a functional head group for interaction with the surface and a tail group for a chemical differentiation of the patterned and unpatterned regions; and

applying a thin film material in liquid solution to the surface of the substrate, the thin film material only coating a second portion of the surface, the second portion not being coated by the organic molecular so there is not a need for further post deposition processing.

31. (New) The method of Claim 14 wherein said radiation is light.

32. (New) The method of Claim 14, wherein said mask is a photomask.

33. (New) A method of forming a patterned thin film, immersing a substrate, selected from the group consisting of a metal, a metal oxide, a semiconductor, a metal alloy, a semiconductor alloy, a polymer, an organic solid and a combination thereof, into a surface derivatizing liquid solution of an organic molecular species, said organic molecular species having reactive functional head groups and tail groups;

said substrate being immersed in contact with said liquid solution of said organic molecular species at a temperature and for a time period sufficient to allow said functional head group to chemically react with and chemically bind to and pack onto a surface of said substrate and interact with adjacent molecules to form a single chemical entity which is a relatively ordered molecular monolayer that is chemically bound to said substrate forming a self-assembled mono-molecular layer, said organic molecular species functional head group being selected from the group consisting of a phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphate, phosphite, phosphazene, azide,

hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, siloane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl), selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate and a combination thereof.

said tail group provides means for chemical differentiation of patterned and unpatterned regions of a coated surface, organic molecular species functional tail group selected from the group consisting of: a hydrocarbon, partially halogenated hydrocarbon, fully halogenated hydrocarbon, phosphine, phosphonic acid, carboxylic acid, thiol, epoxide, amine, imine, hydroxamic acid, phosphine oxide, phosphite, phosphate, phosphazine, azide, hydrazine, sulfonic acid, sulfide, disulfide, aldehyde, ketone, silane, germane, arsine, nitrile, isocyanide, isocyanate, thiocyanate, isothiocyanate, amide, alcohol (hydroxyl), selenol (selenide), nitro, boronic acid, ether, thioether, carbamate, thiocarbamate, dithiocarbamate, dithiocarboxylate, xanthate, thioxanthate, alkylthiophosphate, dialkyldithiophosphate and a combination thereof;

withdrawing said substrate containing said self-assembled mono-molecular layer thereon and placing a mask having one or more transparent and opaque regions onto a top surface of said self-assembled mono-molecular layer on said substrate;

exposing said self-assembled molecular layer to radiation, modulated spatially in intensity in regions defined by said one or more of said regions in said mask transparent to radiation with the result that said self-assembled mono-molecular layer absorbs incident radiation in said transparent regions, thereby only modifying/removing said self-assembled mono-molecular layer beneath said transparent regions of said mask;

producing a chemically differentiated surface between patterned and unpatterned regions of said substrate surface, so that after modification, said self-assembled mono-molecular layer has a discontinuous pattern;

immersing said substrate containing said self-assembled mono-molecular layer having said discontinuous pattern into a liquid dipping solution of a thin film material ~~in liquid~~ for a time sufficient to allow a thin film to be physically adsorbed to said substrate forming a thin film comprising a plurality of layers of molecules and/or atoms said liquid dipping solution selected from the group consisting of : an organic molecule, a short-chain organic oligomer, a long-chain organic polymer, a photoreist, an organic-inorganic hybrid material, an organo-metallic complex, a nanoparticle of metal oxide, a nanoparticle of semiconductor, a silica particle, an inorganic salt and a mixture thereof;

removing said substrate from said liquid dipping solution to obtain a patterned article having thin film material only in certain regions thus forming a patterned thin film on said substrate surface; and

wherein after said immersion treatment, said patterned thin film having been formed only on a surface of said substrate is not coated with said self assembled monolayer and the original self-assembled monomolecular layer has a discontinuous pattern;

wherein because said patterned thin film is formed only on said surface of said substrate not coated with said self-assembled monolayer, there is no need for further post-deposition processing.